

AMENDMENTS TO THE CLAIMS

A detailed listing of all claims that are, or were, in the present application, irrespective of whether the claim(s) remains under examination in the application are presented below. The claims are presented in ascending order and each includes one status identifier. Those claims not cancelled or withdrawn but amended by the current amendment utilize the following notations for amendment: 1. deleted matter is shown by strikethrough for six or more characters and double brackets for five or less characters; and 2. added matter is shown by underlining.

1. (Currently amended) A method for detecting surge in a refrigeration system, said refrigeration system including a centrifugal compressor having an impeller and a compressor entrance, an evaporator that receives a fluid refrigerant, a suction line that flows said refrigerant from said evaporator to said compressor entrance, said evaporator including a heat-exchange coil supplied with a liquid through a supply line entering said evaporator, said liquid disposed in a heat-exchange relationship with said refrigerant within said evaporator, the method comprising automatically and periodically performing the steps of:

measuring a fluid temperature of said liquid proximate said supply line entering said evaporator;

measuring a refrigerant temperature of said refrigerant proximate said compressor entrance; [[and]]

using said fluid temperature and said refrigerant temperature to detect surge in said refrigeration system by computing a value indicative of a temperature difference between said fluid temperature and said refrigerant temperature; and comparing said value to a set point temperature.

2. (Canceled)

3. (Original) The method of claim 1, wherein the step of using said fluid temperature and said refrigerant temperature to detect surge comprises:

generating a compressor-status parameter indicative of an operating condition of said centrifugal compressor;

deriving a set point parameter from said compressor-status parameter;

computing a value indicative of a temperature difference between said fluid temperature and said refrigerant temperature; and

comparing said value to said set point parameter.

4. (Original) The method of claim 3, wherein said operating condition of said centrifugal compressor is selected from a set consisting of: off-state, starting and normal running.

5. (Original) A method for detecting surge in a centrifugal compressor having a compressor entrance in fluid communication with an evaporator, said evaporator adapted to receive a fluid refrigerant and disposed in a heat-exchange relationship with a liquid entering said evaporator at a suction entrance and flowing through a heat-exchange coil located in said evaporator, said method comprising automatically and periodically performing the steps of:

generating a compressor-status parameter which defines an operating condition for said centrifugal compressor;

calculating a set point parameter in accordance with said compressor-status parameter;

positioning a first temperature sensor proximate said compressor entrance to measure a refrigerant temperature;

positioning a second temperature sensor near said suction entrance to measure a liquid temperature; and

using said liquid temperature, said refrigerant temperature and said set point temperature to detect surge.

6. (Currently amended) A method for detecting surge in a centrifugal compressor having a compressor entrance fluidly connected to an evaporator, said evaporator flowing a refrigerant, said refrigerant received from a condenser and disposed in heat-exchange relationship with a liquid entering said evaporator at a suction entrance, said method comprising automatically and periodically performing the steps of:

determining a first thermodynamic parameter at a first location within said liquid proximate said evaporator ~~outlet entrance~~;

determining a second thermodynamic parameter at a second location within said refrigerant proximate said compressor; and

detecting surge from said first and said second thermodynamic parameters by computing a value indicative of a parameter difference between said first thermodynamic parameter and said second thermodynamic parameters; and comparing said value to a set point parameter.

7. (Original) The method of claim 6, wherein the first thermodynamic parameter is temperature.

8. (Original) The method of claim 6, wherein the second thermodynamic parameter is temperature.

9. (Original) The method of claim 6, wherein the step of detecting surge further comprises:

periodically determining an operational condition of said centrifugal compressor; and  
obtaining a parameter indicative of surge from said first thermodynamic parameter, said second thermodynamic parameter and said operational condition.

10. (Original) The method of claim 9, wherein said operational condition of said compressor is selected from a set consisting of: off-state, starting and normal running.

11. (Original) An apparatus for detecting surge in a centrifugal compressor in fluid communication with an evaporator at a compressor entrance, said evaporator flowing a refrigerant fluid in heat-exchange relationship with a liquid entering said evaporator proximate a evaporator suction entrance, said apparatus comprising:

means for detecting a first temperature of said refrigerant proximate said compressor entrance;

means for detecting a second temperature of said liquid proximate said evaporator suction entrance;

means for determining a differential between said first temperature and said second temperatures; and

means for detecting surge by comparing said differential to a set point parameter.

12. (Original) The apparatus of claim 11, wherein said means for detecting said first temperature is a temperature sensor.

13. (Original) The apparatus of claim 12, wherein said means for detecting said second temperature is a temperature sensor.

14. (Original) The apparatus of claim 11, wherein said means for determining said differential and said means for detecting surge are implemented as an operative arrangement selected from the set consisting of: analog circuitry, a digital processor, software, firmware or any combination thereof.

15. (Original) The apparatus of claim 14, wherein said means for determining said differential controls an operation condition of said centrifugal compressor responsive to said differential.

16. (Original) A method for detecting surge in a centrifugal compressor connected in series and in fluid communication with an evaporator at a compressor entrance, said evaporator flowing a refrigerant fluid in heat-exchange relationship with a liquid entering said evaporator proximate a evaporator suction entrance, said method comprising the step of:

periodically comparing a temperature differential between a first temperature measured in said refrigerant fluid proximate said compressor entrance and a second temperature measured in said liquid proximate said evaporator suction entrance to a set point temperature indicative of an operating condition of said centrifugal compressor.

17. (Original) The method of claim 16, wherein said operating condition of said centrifugal compressor is selected from a set consisting of: off-state, starting and normal running.

18. (Original) A method for detecting surge in a centrifugal compressor connected in series and in fluid communication with an evaporator at a compressor entrance, said evaporator flowing a refrigerant fluid in heat-exchange relationship with a liquid entering said evaporator proximate a evaporator suction entrance, said method comprising the step of:

periodically comparing a rate of change of a temperature differential between a first temperature measured in said refrigerant fluid proximate said compressor entrance and a second temperature measured in said liquid proximate said evaporator suction entrance to a set point temperature indicative of an operating condition of said centrifugal compressor.

19. (Original) The method of claim 18, wherein said operating condition of said centrifugal compressor is selected from a set consisting of: off-state, starting and normal running.

20. (Original) A method of detecting surge in a centrifugal compressor having an impeller and a compressor entrance in fluid communication with said impeller, said compressor entrance connected to a evaporator, said evaporator adapted to receive refrigerant from a condenser, said refrigerant disposed in heat-exchange relationship with a liquid entering said evaporator at a evaporator suction entrance and flowing within a heat-exchange coil disposed in said evaporator, the method comprising the steps of:

monitoring a first temperature of said refrigerant before said refrigerant enters said compressor entrance;

monitoring a second temperature of said liquid before said liquid enters said evaporator suction entrance; and

detecting surge from calculations involving said first temperature, said second temperature and a set point temperature.

21. (Original) The method of claim 20, wherein the step of detecting surge from calculations comprises the steps of:

detecting surge responsive to a deviation of a temperature difference between said first temperature and said second temperature from a set point parameter indicative of an operating condition of said centrifugal compressor by a selected amount.

22. (Original) The method of claim 21, wherein said deviation of said temperature difference from said set point is measured by an operative arrangement selected from the set consisting of: analog circuitry, a digital processor, software, firmware or any combination thereof.

23. (Original) The method of claim 21, wherein said operating condition of said centrifugal compressor is selected from a set consisting of: off-state, starting and normal running.

24. (Currently amended) A method for detecting surge in a refrigeration system, said refrigeration system including a centrifugal compressor means having an impeller and a compressor entrance, an evaporator means for receiving a fluid refrigerant, a suction line for

flowing said refrigerant from said evaporator means to said compressor entrance, said evaporator means including a heat-exchange coil means supplied with a liquid through a supply line entering said evaporator means, said liquid disposed in a heat-exchange relationship with said refrigerant within said evaporator means, the method comprising automatically and periodically performing the steps of:

measuring a fluid temperature of said liquid proximate said supply line entering said evaporator means;

measuring a refrigerant temperature of said refrigerant proximate said compressor entrance; [[and]]

using said fluid temperature and said refrigerant temperature to detect surge in said refrigeration system by periodically determining an operational condition of said centrifugal compressor means; and

obtaining a parameter indicative of surge from said fluid temperature, said refrigerant temperature and said operational condition.

25. (Original) The method of claim 24, wherein said step of measuring said fluid temperature comprises the steps of:

positioning a first temperature sensor proximate said supply line entering said evaporator.

26. (Original) The method of claim 24, wherein said step of measuring said refrigerant temperature comprises the steps of:

positioning a second temperature sensor proximate said compressor entrance.

27. (Canceled)

28. (Currently amended) The method of claim 2[[7]]4, wherein said operational condition of said compressor is selected from a set consisting of: off-state, starting and normal running.

29. (Original) The method of claim 24, wherein the step measuring said refrigerant temperature includes the step of:

positioning a second temperature sensor in said suction line in the vicinity of said compressor entrance.

30. (Canceled)

31. (Original) The method of claim 24, wherein the step measuring said refrigerant temperature includes the step of:

positioning a second temperature sensor proximate said impeller.